Milena Mozzo

FUNCTIONAL ARCHITECTURE OF PHOTOSYNTHETIC LIGHT HARVESTING COMPLEXES

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Ai miei amici

Succes!

Preface

Light is an electromagnetic radiation composed of elementary particles called photons and can be classified based on three primary properties: brightness, wavelength and polarization.
Interaction of light with living matter is a fundamental topic in life sciences. The reason is easily explained: the Sun, the light source in our planet, permits development, sustenance and regulation of almost all form of life.
Among the different light-induced processes, photosynthesis is fundamental and unique because it enables the transformation of the light energy in chemical energy.
Beside the fascination of the curiosity-driven studies of photosynthesis, the unravelling of structural and functional organisation of the photosynthetic apparatus can offer the opportunity to mimic the process, with the aim of energy production.
Moreover, unrevealing the role of individual complexes composing the light-converting machinery can allow identifying resistance and photoprotection mechanisms which allow photosynthetic organisms to adapt to climate changes.

This thesis exploits the properties of light for investigating the early processes of photosynthesis: light harvesting and photoprotection.
The main subjects of this study are the antenna complexes, that are chlorophylls-carotenoids binding proteins composing the photosynthetic apparatus. The antennae capture and efficiently transfer excitation energy to the reaction centre, where the first chemical reaction of the process takes place. Furthermore, in high light conditions, these complexes can efficiently dissipate the excess of harvested light energy, thus protecting the photosynthetic organisms from photo-damages.

The enormous progress in structure determination of membrane proteins, together with the development of spectroscopic methods of very high time resolution, offer the basis to get insight on the properties of antenna complexes.
Combining mutation analysis with spectroscopic measurements, the properties of pigments bound to the antenna complexes of green plants are determined. Moreover, the data are used as starting point for finely probing the pigment-protein environment of different antennae and investigating the roles of individual pigments, in light harvesting and photoprotection.

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Abbreviations and symbols

Abs, absorption
Asn (or N), asparagine
a.u., arbitrary units
ADMR, absorbance-detected magnetic resonance
ATP (or ADP), adenosine tri (or di-) phosphate
B_x, B_y, higher energy optical absorption bands (Soret band) of phorphyrins
Car, carotenoid
$^1Car^*$, $^3Car^*$, lowest singlet and lowest triplet excited states of carotenoid
CD, circular dichroism
Chl, chlorophyll
$^1Chl^*$, $^3Chl^*$, lowest singlet and lowest triplet excited states of chlorophyll
CP *X*, chlorophyll binding protein of molecular mass *X*
Cyt, cytocrome
DM, n-dodecyl maltopyranoside
DNA, deossiribonucleic acid
F, phenylalanine
Fd, ferredoxin
FDMR, fluorescence-detected magnetic resonance
FNR, ferredoxin $NADP^+$ reductase
FWHM, full width at half maximum
Glu, glutamic acid
Gln, glutamine
H^+, H_2 hydrogen ion and molecular forms
Hepes, n-2-hydroxyethyl-piperazine
His (or H), histidine
HPLC, high-performance liquid chromatography
IEF, isoelectrofocusing
KDa, kilo dalton
L (or Lut), lutein
L1, L2, carotenoid binding sites
LHCI (or Lhca) Light harvesting complexes of Photosystem I
LHCII (or Lhcb) Light harvesting complexes of Photosystem II
LT, low temperature
M, measurement
Mg, magnesium

N (or Neo), neoxanthin
N1, carotenoid binding site
$NAD(P)^+$, NAD(P)H, nicotinamide adenine (phospho) dinucleotide (oxidized and reduced)
nm, nanometer
NPQ, non photochemical quenching
$^3O_2$, ground state of molecular oxygen
$^1O_2^*$ lowest singlet excited state of molecular oxygen
O.D., optical density
OPO, optical parametric oscillator
ORF, open reading frame
PC, plastocyanin
P680, photochemically active pigment (or electron donor) of PSII
P700, photochemically active pigment (or electron donor) of PSI
pQE, pET, bacterial expression vectors
PG, phosphatidylglycerol
PQ, PQH_2 plastoquinone, plastoquinol
PSI (II), Photosystem I (II)
Psa *X*, subunit *X* of PSI RCs
PsbS, 22KDa PSII protein
qE, energy dependent quenching
Q_x, Q_y, low energy absorption bands of porphyrins
R, reference
RC, reaction centre
ROS, reactive oxygen species
RT, room temperature
S_{1-0} or S_{2-0}, singlet excited states of chlorophylls
SDS-PAGE, sodium dodecyl sulphate polyacrylamide gel electrophoresis
TmS, triplet minus singlet
V (or Viola), violaxanthin
V1, carotenoid binding site
WT, wild type
w/v, weight per volume
Z (or Zea), zeaxanthin
Å, angstrom
ε, molar extinction coefficient (M^{-1} cm^{-1})
λ, wavelength (nm)
τ, lifetime

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